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Jawaharlal Nehru
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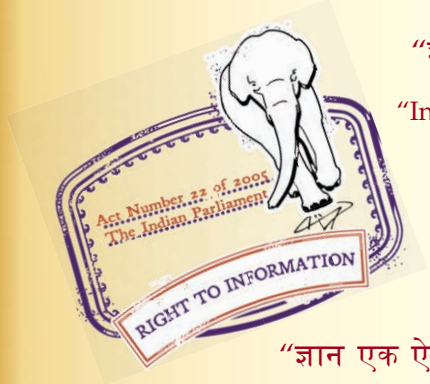
IS 11551 (1996): Glass fibre chopped strand mat for the reinforcement of epoxy, phenolic and polyester resin systems [PCD 12: Plastics]

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Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

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IS 11551 : 1996
( Reaffirmed 2001 )

भारतीय मानक

# एपॉक्सी, फीनॉलिक तथा पोलीयस्टर रेज़िन प्रणाली के पुनःप्रबलन के लिए शीशा रेशे के कटे लड़दार मेट

( पहला पुनरीक्षण )

*Indian Standard*

# GLASS FIBRE CHOPPED STRAND MAT FOR THE REINFORCEMENT OF EPOXY, PHENOLIC AND POLYESTER RESIN SYSTEMS — SPECIFICATION

*( First Revision )*

ICS 59.100.10; 83.080.10



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NEW DELHI 110002

*December* 1996

Price Group 6

FOREWORD

This Indian Standard ( First Revision ) was adopted by the Bureau of Indian Standards, after the draft finalized by the Plastics Sectional Committee, had been approved by the Petroleum, Coal and Related Products Division Council.

Chopped strand mats are generally available for use in the hand lay-up process, the production of translucent sheeting, matched metal die moulding and the production of sheet moulding compound.

The reinforced plastics industry in India has been making consistent progress since the past two decades. While thermoset polyester resins have been predominantly used as the matrix for reinforcement by glass fibre chopped strand mat, epoxy resins and phenolic resins have also started being used in recent times. Epoxy resins having good resistance to chemicals especially mild alkalis, glass fibre chopped strand mat reinforced with epoxy resins find wide usage and have immense potential especially for corrosion resistance and electrical applications. On the other hand phenolic resins having inherent fire retardance and glass fibres being incombustible, the glass fibre reinforced phenolic resin systems have high temperature resistance and fire retardance compared to conventional polyester resin system. Again, the requirements of glass fibre chopped strand mat for use with phenolic resin systems is different from that of polyester resin systems with respect to moulding parameters, mechanical properties of moulded product, etc. The method of cure of phenolic resin system is also different from that of polyester resin system. Likewise, the method of using epoxy resin system with chopped strand mat differs from polyester resin system.

This standard was first published in 1986 covering 'E'-glass chopped strand mat intended for use as reinforcement with polyester resin systems only. However, keeping in view the present trend in the Indian Industry and the advancements those have taken place elsewhere in the world in the reinforced plastics industry, the concerned technical Committee while reviewing the standard decided to revise the standard broadening its scope to cover the requirements for the reinforcement of epoxy resin systems and phenolic resin systems in addition.

The physical characteristics of the mat used in each application are decided by the customer's preference and hence no attempt has been made to define them in the standard. It is strongly recommended that the intended use of chopped strand mat be fully discussed with the supplier before ordering. It is necessary that the width, loss on ignition and average mass per unit area requirements be also carefully looked into while using the specification.

This standard contains requirements which call for agreement between the purchaser and the supplier. Apart from this test methods for wet-out time of the chopped strand mat, breaking strength of the mat, mat binder solubility and the maximum and minimum resin pick-up have been included in the standard for information which may help the purchaser to ensure the consistency in processibility and uniformity in quality.

Information regarding the requirements for the quality of epoxy resins and phenolic resin systems are given in Annexes of this standard for guidance only. Requirements for the quality of polyester resin systems have been covered in IS 6746 : 1994 'Unsaturated polyester resin systems — Specification'.

For the purpose of deciding whether a particular requirements of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values ( *revised* )'. The number of significant places retained in the rounded off value should be the same as that of the specified value in the standard.

*Indian Standard*

# GLASS FIBRE CHOPPED STRAND MAT FOR THE REINFORCEMENT OF EPOXY, PHENOLIC AND POLYESTER RESIN SYSTEMS — SPECIFICATION

*( First Revision )*

## 1 SCOPE

This Indian standard specifies requirements and methods of sampling and tests for 'E'-glass fibre chopped strand mat, the strands being laid at random and held together with a chemical binder, for the reinforcements of epoxy, phenolic and polyester resin systems in accordance with the mat supplier's instructions.

## 2 NORMATIVE REFERENCES

The following standards contain provisions which through reference in text constitute provisions of this standard. At the time of publication the editions indicated were valid. All standards are subject to revisions, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standard indicated below:

| *IS No.* | *Title* |
|---|---|
| 2828 : 1964 | Glossary of terms used in plastics industry |
| 4905 : 1968 | Methods for random sampling |
| 6746 : 1994 | Unsaturated polyester resin systems |

## 3 TERMINOLOGY

For the purpose of this Indian Standard, the definitions given in IS 2828 : 1964 and the following shall apply.

### 3.1 E-glass

A type of glass that does not contain more than 1 percent by mass of alkali, calculated as $Na_2O$ commonly referred to as 'low alkali' glass.

### 3.2 Filament

A single glass fibre as drawn.

### 3.3 Strand

A plurality of filaments bonded with size.

### 3.4 Size

Materials applied to the filaments during manufacture to facilitate processing and use.

### 3.5 Binder

The material applied to chopped strands in order to help them in a desired arrangement as common chopped strands mat.

### 3.6 Coupling Agent

A chemical constituent of size material which forms bonds with the fibre and the matrix resin and hence improves the performance of fibre/resin composite products.

### 3.7 Chopped Strand Mat (CSM)

A mat formed of strands cut to a short length randomly distributed without intentional orientation and held together by a binder.

## 4 REQUIREMENTS

### 4.1 Manufacture

The strand shall be composed of filaments each with an average diameter within the range from 8 to 15 microns. The strand length shall be between 25 and 51 mm. The strands shall contain sizing and binder materials compatible to thermosetting epoxy resins, phenolic resins and the polyester resin systems.

### 4.2 Defect and Impurities

The mat shall be reasonably uniform in colour. It shall be free from discoloured patches, wet patches, poorly bonded surfaces, clumps of strands, clump or strips of binder, dark strands, oil and grease spots and other contaminations.

**4.3** The mat shall also comply with the requirements given in Table 1.

### 4.4 Keeping Properties

Unless otherwise agreed to, the mat shall comply with

## Table 1 Requirements for Mat

( *Clause* 4.3 )

| Sl No. | Characteristics | Requirements | | | Method of Test, Ref to |
|---|---|---|---|---|---|
| | | For Use with Epoxy Resins | For use with Phenolic Resins | For use with Polyester Resins | |
| (1) | (2) | (3) | (4) | (5) | (6) |
| i) | Width, mm ( *see* Note 1 ) | 520,1 040,1 560, 2 080 or as agreed to between the supplier and the purchaser | 520, 1 040,1 560, 2 080 or as agreed to between the supplier and the purchaser | 1 000,1 500 or as agreed to between the supplier and the purchaser | |
| ii) | Moisture content, percent by mass, *Max* | 0.5 | 0.5 | 0.5 | Annex A |
| iii) | Loss on ignition, percent by mass ( *see* Note 2 ) | 3.5- 6.5, or as agreed to between the supplier and the purchaser | As agreed to between the supplier and the purchaser | As agreed to between the supplier and the purchaser | Annex B |
| iv) | Average mass per unit area, g/m² ( *see* Note 3 ) | 300, 450, 600, 900 or as agreed to between the supplier and the purchaser | 300,450,600, 900 or as agreed to between the supplier and the purchaser | 300, 450, 600, 900 or as agreed to between the supplier and the purchaser | Annex C |
| v) | Percentage variation in mass per unit area | Individual specimens not more than 19 percent from the nominal mass per unit area and the range not to exceed the following from the nominal mass per unit area: | | | Annex D |
| | *Width of CSM* | *No. of Specimen* / *Range* | *No. of Specimen* / *Range* | *No. of Specimen* / *Range* | |
| | 520 mm | 1 / – | 3 / 22 percent | 3 / 22 percent | |
| | 1 040 mm | 3 / 22 percent | 4 / 23 percent | 4 / 23 percent | |
| | 1 560 mm | 5 / 24 percent | 5 / 24 percent | 5 / 24 percent | |
| | 2 080 mm | 6 / 25 percent | 6 / 25 percent | 6 / 25 percent | |
| vi) | Cross-breaking strength of laminates (MPa*) (Glass content 32 percent by mass) | Dry - 205, *Min* Wet - 155, *Min* | Dry - 150 to 180 Wet - 120 to 144 | Dry - 180, *Min* Wet - 135, *Min* | Annex E |
| vii) | Conductivity of water extract (mS/m), *Max* ( *see* Note 4 ) | 1.25 | | | Annex F |

NOTES

1 A tolerance of ± 30 mm at any point may be allowed only to mat trimmed on both edges.

2 A tolerance of ± 2 percent may be allowed.

3 A tolerance of ± 7 percent may be allowed.

4 mS/m = 10 micromhos per cm.

* MPa = 1 MN/m² ( One newton = 0.101 972 kg ).

the requirements of this standard for a period of not less than one year when stored at a temperature not exceeding 25°C and a relative humidity not exceeding 65 percent.

## 5 PACKING AND MARKING

### 5.1 Packing

The mat shall be rolled on a tube, the roll shall be enclosed in a polyethylene bag and packed in a suitable container in such a manner as to prevent free movement. Not more than three pieces shall be permitted in one roll and no piece shall be less than 5 m in length.

### 5.2 Marking

Each roll or its container shall be clearly marked with the following information:

a) Indication of the source of manufacture, trade-mark, if any;
b) The nominal width of the roll ( m );
c) The nominal length of the roll ( m );
d) The nominal mass per unit area of the mat ( $g/m^2$ );
e) The actual mass of the roll ( kg );
f) Suitable for use with the type of resin systems; and
g) Month and year of the manufacture.

### 5.3 BIS Certification Marking

The material may also be marked with the Standard Mark.

**5.3.1** The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of condition under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

## 6 SAMPLING AND CRITERIA FOR CONFORMITY

### 6.1 Sampling

**6.1.1** *Lot*

All the rolls in a single consignment of the material of the same type and from a single batch of manufacture shall constitute a lot.

**6.1.2** Samples shall be tested for each lot separately for ascertaining the conformity of the material to the requirements of the specification.

**6.1.3** The number of rolls to be selected from the lot shall depend on the size of the lot and shall be in accordance with Table 2.

**Table 2 Number of Rolls to be Selected for Sampling**
( *Clauses* 6.1.3 *and* 6.2.2 )

| Lot Size | No. of Rolls to be Chosen | |
|---|---|---|
| | Moisture, Average Mass per Unit Area and Percentage Variation in Mass per Unit Area | Width, Loss on Ignition and Conductivity of Water Extract |
| (1) | (2) | (3) |
| 1 | 1 | 1 |
| 2 to 15 | 2 | 2 |
| 16 to 50 | 3 | 2 |
| 51 to 100 | 5 | 3 |
| 101 and above | 7 | 5 |

**6.1.4** These rolls shall be selected at random from the lot. In order to ensure the randomness of selection, procedures given in IS 4905 : 1968 may be followed.

### 6.2 Number of Tests and Criteria for Conformity

**6.2.1** From each of the rolls selected according to **6.1.3**, required number of samples for testing different characteristics shall be prepared. For this purpose, from each of the rolls selected, required number of specimens shall be cut.

**6.2.2** Each of the samples obtained above shall be examined for visual defects ( *see* **4.2** ), moisture, average mass per unit area and percentage variation in mass per unit area, and if found satisfactory, further tests as specified under col 3 of Table 2 shall be carried out.

**6.2.3** For cross breaking strength, one roll shall be selected irrespective of the size of the lot. It may be selected from these rolls which have been passed according to **6.2.2**. The required number of specimens shall be cut from this roll and tested for this characteristic according to the procedure given in Annex E.

**6.2.4** The lot shall be declared as conforming to the requirements of the specification if there is no failure according to **6.2.2** and **6.2.3**.

# ANNEX A

[ *Table* 1, *Sl No.* ( ii ) ]

## DETERMINATION OF MOISTURE CONTENT

### A-1 PROCEDURE

**A-1.1** Cut three specimens of mat, each of approximately the same mass between 2 and 5 g from the roll of mat to be tested. Cut one specimen from each side and from the centre at the open end of the mat. Weigh to the nearest 5 mg, the collective mass of the three specimens ( mass *A* ). Dry the specimens in a forced oven at 105 ± 2°C for one hour. Allow them to cool in a desiccator and record the collective mass to the nearest 5 mg ( mass *B* ).

### A-2 CALCULATION

**A-2.1** Moisture content, percent by mass $= \frac{A - B}{A} \times 100$

where

$A$ = original mass of the specimens, and

$B$ = mass of the oven-dried specimens.

NOTE — The dried specimens shall be used for the determination of the loss on ignition.

# ANNEX B

[ *Table* 1, *Sl No.* ( iii ) ]

## DETERMINATION OF LOSS ON IGNITION

### B-1 PROCEDURE

**B-1.1** Heat the dried specimens ( mass *B* ) from the determination of moisture content ( Annex A ) in a suitable container in a muffle furnace for not less than 20 min at a temperature of 575 ± 25°C. After removal from the muffle furnace cool the specimens in a desiccator to room temperature and reweigh. Record the collective mass to the nearest 5 mg ( mass *C* ).

### B-2 CALCULATION

**B-2.1** Loss on ignition, percent by mass $= \frac{B - C}{B} \times 100$

where

$B$ = mass of the oven-dried specimens, and

$C$ = mass of the specimens after ignition.

NOTE — This method determines the total organic content that is derived from both the size applied to the filaments and the mat binder. The total organic content is commonly referred to as the 'binder content'.

# ANNEX C

[ *Table* 1, *Sl No.* ( iv ) ]

## DETERMINATION OF MASS PER UNIT AREA

### C-1 PROCEDURE

**C-1.1** Read the nominal length in m and width in cm from the packing. Weigh the roll to determine net mass of mat. Calculate average mass per unit area as in **C-2**.

### C-2 CALCULATION

**C-2.1** Determine the mass per unit area for each roll as follows:

$$\text{Mass per unit area g/m}^2 = \frac{100\ D}{L \times W}$$

where

$D$ = net mass of mat in the roll (g),

$L$ = nominal length of mat in the roll (m), and

$W$ = nominal width of mat (cm).

# ANNEX D

[ Table 1, Sl No. ( v ) ]

## DETERMINATION OF PERCENTAGE VARIATION IN MASS PER UNIT AREA

### D-1 PROCEDURE

**D-1.1** Cut specimens, each 400 × 250 mm, from the mat, with the long side parallel to the length direction of the mat, the number of specimens being taken in accordance with the following table:

| *Width of Mat (cm)* | *Number of Specimens* |
|---|---|
| 50 up to but excluding 120 | 3 |
| 120 up to but excluding 150 | 4 |
| 150 up to but excluding 180 | 5 |
| 180 up to but excluding 210 | 6 |
| 210 and over | As agreed to between the supplier and the purchaser |

Untrimmed mats shall be trimmed to the appropriate nominal width before the specimens are taken.

For widths of 75 cm and above, take the specimens in line across the width of the mat, cutting one for each side of the mat to include the edge, and the remainder at a regular spacing from the intervening width. For widths of less than 75 cm, cut the specimens as shown in Fig. 1.

Weigh each specimen to the nearest 0.5 g and determine the relationships.

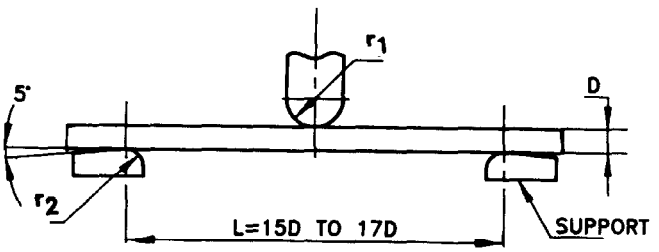


FIG. 1 ARRANGEMENT OF TEST SPECIMENS

NOTE — This test is not applicable to mats less than 50 cm wide.

### D-2 CALCULATIONS

**D-2.1** The percentage variation in mass per unit area

$$A = \frac{100\,(10\,m - M)}{M}$$

where

$m$ = mass of specimen (g), and

$M$ = nominal mass per unit area (g/m$^2$).

The range of percentage variation in mass per unit area

$$R = \frac{1\,000\,(mH - mL)}{M}$$

where

$mH$ = mass of the heaviest specimen ( g ),

$mL$ = mass of the lightest specimen ( g ), and

$M$ = nominal mass per unit area ( g/m$^2$ ).

# ANNEX E

[ *Clause* 6.2.3 and *Table* 1, *Sl No.* ( vi ) ]

## DETERMINATION OF CROSS BREAKING STRENGTH OF LAMINATES

### E-1 PREPARATION OF LAMINATE

**E-1.1** Cut the requisite number of specimens of mat each approximately 300× 275 mm, square to the roll, with the longer sides parallel to the length direction of the mat. This number shall be sufficient to provide a total mass of mat of approximately 150 g for example:

Six specimens from 300 g/m$^2$ mat

Four specimens from 450 g/m$^2$ mat

Three specimens from 600 g/m$^2$ mat

Two specimens from 900 g/m$^2$ mat

Dry the specimens in a ventilated oven for one hour at 105 ± 2°C, remove from the oven, allow to cool and use within one hour of removal. Impregnate the specimens with resin conforming to relevant specifications to give a final glass content from 30 to 40 percent of the total mass, the criterion for thorough impregnation and compatibility being that the wet lay-up shall be uniformly translucent, depending upon the

type of resin systems used, viz. polyester, epoxy and phenolic pink/red in colour. Both impregnation and building up of the laminate shall be done at room temperature of between 17 and 25°C. A suitable method is as follows:

Calculate the mass of resin necessary to give the required resin/glass ratio from the mass of mat to be used. Formulate a quantity of resin, in excess of this, according to the manufacturer's instructions.

*For Epoxy Resin Systems*

Hardener percentage varies from 10 to 12 on the basis of resin weight. If any reactive diluent is used ( additional level is generally 10-15% ) for reducing viscosity and if it is an epoxy compound then total amount of hardener shall be calculated on the total weight of resin and diluent. The pot life of the system at 10 to 12 percent hardener level and at 25°C would range from 30 to 45 minutes.

Wooden platform or FRP or metallic mould is used for the purpose of laminate preparation. Wax/ polyvinyl alcohol or silicone based chemical is used as releasing agent. Spread roughly the correct proportion of the catalysed resin uniformly on the mould after applying the release agent and drying the same. Place one specimen on the resin and consolidate using a suitable laminating roller until the mat is fully impregnated and all obvious air inclusions are removed from the laminate. Repeat this procedure with alternate layers of resin and mat until the build up is complete. Superimpose each specimen on its predecessor so that the longer sides are parallel.

NOTE — If the viscosity of the resin seems too high for brushing, then heat the resin ( before addition of hardener) at 35°C for 10 minutes to bring it down to the brushable range.

*For Phenolic Resin Systems*

Wooden platform or epoxy mould is used for the purpose of laminate preparation. Carnauba Wax or Polytetrafluroethylene ( PTFE ) is used as releasing agent. Spread roughly the correct proportion of the catalysed resin uniformly on the mould after applying the releasing agent and drying the same. Place one specimen on the resin and consolidate using a suitable laminating roller until the mat is fully impregnated and all obvious air inclusions are removed from the laminate. Repeat this procedure with alternate layers of resin and mat unitl the build-up is complete. Superimpose each specimen on its predecessor so that the longer sides are parallel.

*For Polyester Resin Systems*

Cover a polished metal plate, or glass plate, of suitable size with a sheet of regenerated cellulose film, or polyethylene terephthalate film of about 0.05 mm thick. Spread roughly the correct proportion of the catalysed resin uniformly on the film. Place one specimen on the resin and consolidate using a suitable laminating roller until the mat is fully impregnated and all obvious air inclusives are removed from the laminate. Repeat this procedure with alternate layers of resin and mat until the build-up is complete. Superimpose each specimen on it predecessor so that the longer sides are parallel.

When all the specimens have been impregnated, cover the top with a sheet of film, followed by a second plate. Place stops of the required thickness, as calculated from Fig. 2, between the upper and lower plates. Within 5 minutes of the completion of these operations, place the whole lay-up between the platens of a press, which shall be cleared and adjusted so that the plates are closed to the stops and held under light pressure during the curing schedule.

Cure the laminate in accordance with the resin supplier's instructions. Post cure for two hours at 100 ± 5°C; it shall be reasonably free from visible voids and other defects. Cool to room temperature and trim approximately 10 mm from all edges of the laminate.

## E-2 TEST PROCEDURE

### E-2.1 General

Cut 20 rectangular strips not less than 100 mm long and 20 ± 2 mm wide, ten each with the longer direction parallel to the longitudinal and transverse directions of the original roll of the mat. Determine the cross breaking strengths of these strips as follows:

The test shall be carried out in a standard atmosphere. The width of the specimen shall be measured to the nearest 0.1 mm and the thickness to the nearest 0.02 mm.

The specimen shall be placed symmetrically across two parallel supports as shown in Fig. 1. The surface of the supports where they are in contact with the specimen shall have a radius ( $r_2$ ) of 4.8 to 5.2 mm for testing specimens of thickness not greater than 3 mm and a radius of 1.8 to 2.2 mm for specimens of thickness greater than 3 mm. The distance between the supports shall be 15 to 17 times the measured thickness of the specimen and a force shall be applied uniformly across the width of the specimen by means of a loading member parallel with the midway between the supports as

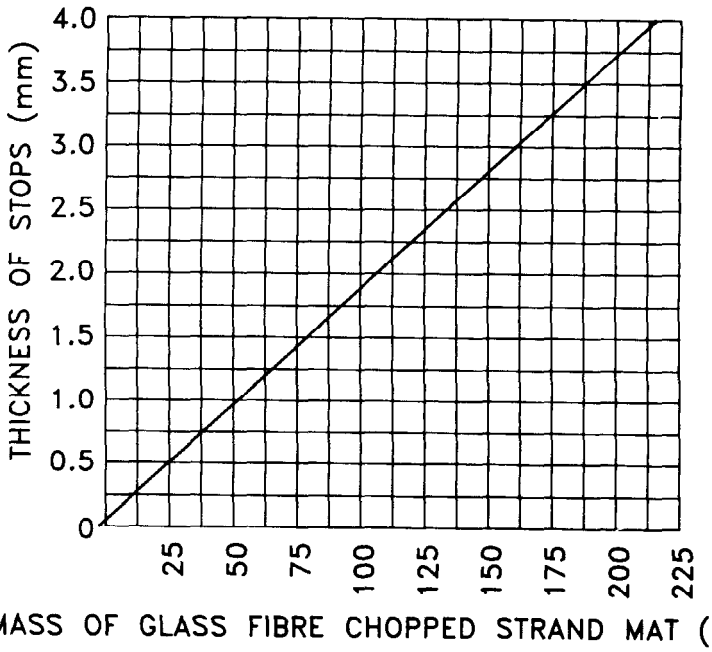


FIG. 2 MASS OF GLASS FIBRE CHOPPED STRAND TO PRODUCE 300 × 275 mm LAMINATE WITH A GLASS CONTENT OF 42.5 PERCENT BY MASS

shown in Fig. 1. The radius ($r_1$) of the end of the loading member shall be 4.9 to 5.1 mm (*see* Fig. 1).

The force shall be increased steadily from zero by a relative movement of the loading member and the supports at an approximately constant rate of 10 to 15 mm/min.

The force at fracture shall be noted and shall be within 1 percent of the true value. Results obtained on specimens that break outside the middle third part of the length between the supports shall be discarded and additional specimens tested in their place. Results obtained on specimens that fail by splitting along laminations shall be treated with caution.

The cross-breaking strength of the specimen shall be calculated as follows:

$$\text{Cross breaking strength} = \frac{1.5\,Fl}{bd^2}$$

where

$F$ = force at fracture,
$l$ = distance between supports,
$b$ = width of specimen, and
$d$ = thickness of specimen.

The cross-breaking strength of the material under test shall be reported as the arithmetic mean of the cross-breaking strengths of the test specimens.

**E-2.2 Dry Conditioning**

Test five longitudinal test specimens and five transverse test specimens in the dry condition as soon as convenient after cutting. Report the mean cross-breaking strength of the ten specimens. After testing, determine the resin content of the dry test specimens as follows:

A crucible of appropriate dimensions shall be heated in a muffle furnace at 575 ± 25°C for 15 minutes, cooled in a desiccator and weighed ($W_1$). The test specimen shall be placed in the crucible and the crucible contents are heated in an oven at 105°C to 110°C for 2 h. The crucible and contents shall then be cooled in a desiccator, weighed and returned to the oven for a further 30 minutes, cooled and reweighed and the procedure repeated until the mass ($W_2$) of crucible and specimen becomes constant to within 0.01 g.

The crucible and contents shall then be heated in a ventilated muffle furnace at a temperature of 575 ± 25°C until the residue of glass fibre is white in colour (approx. 30 minutes). The crucible and contents shall then be removed from the furnace allowed to cool in a desiccator and weighed. This process of heating, cooling and weighing shall then be repeated until the mass ($W_3$) becomes constant to within 0.01 g. The resin content of the test specimen shall be calculated as follows:

$$\text{Percentage resin content} = \frac{(W_2 - W_3)}{(W_2 - W_1)} \times 100$$

The resin content of the material under test shall be reported as the arithmatic mean of the results obtained on the test specimens.

**E-2.3 Wet Conditioning**

Immerse five longitudinal test specimens and five transverse test specimens in boiling distilled water for 2 h and cool in distilled water to room temperature. Wipe to remove excess water and test immediately. Report the mean cross-breaking strength of the test specimens.

## ANNEX F

[ *Table* 1, *Sl No.* ( vii ) ]

### DETERMINATION OF CONDUCTIVITY OF WATER EXTRACT

**F-0 GENERAL**

The method of preparing hot water extract is given in **F-1**. For this, low-conductivity water shall be used and the flasks shall be thoroughly steamed out immediately before use. Conductivity shall be measured according to **F-2**.

**F-1 HOT WATER EXTRACTION**

**F-1.1** Condition the sample in the standard atmosphere for testing for at least 24 h. Take from the conditioned sample a specimen of convenient weight and transfer it to the flask, add to the flask 20 ± 0.1 ml water per gram of specimen. Connect the flask to a reflux condenser, bring rapidly to boil and continue to boil the liquor gently for 60 min. Disconnect and remove the flask while the liquid is still boiling and close it immediately with a glass stopper fitted with a stopcock. Do not filter or make up to volume, but cool rapidly to 20 ± 2°C. Do not remove or open the tap until ready to make conductivity measurement. Reject any extract unless there is partial vacuum inside the flask immediately before it is opened.

**F-2 MEASUREMENT OF CONDUCTIVITY**

**F-2.1** Take the extract as prepared in **F-1**. Remove the stopper from the flask and transfer some of the extract to the conductivity cell. Wash the electrodes with two or three changes of extract, re-stoppering the flask as soon as possible.

Measure electrical resistance with the meter. Record the temperature of the extract and calculate the conductivity.

**F-3 CALCULATION**

**F-3.1** Conductivity at $20^{\circ}C = \frac{108\ K}{R\ [\ 1 + 0.02\ (\ t - 20\ )\ ]}$ micromhos per cm

where

$K$ = cell constant in $cm^{-1}$,

$R$ = measured resistance in ohms, and

$t$ = temperature of extract in °C.

## ANNEX G

( *Foreword* )

### DETERMINATION OF WET-OUT TIME OF CHOPPED STRAND MAT

**G-0 GENERAL**

**G-0.1 Outline of the Method**

This test determines the minimum time required for a resin system ( Epoxy, phenolic or polyester ) to completely wet-out a specimen.

**G-1 RESIN**

**G-1.1** The recommended viscosity of the resin used in this test should be 500-650 cps at 25°C for phenolic resin, 4 000–12 000 cps at 25°C for epoxy resin and 660 centistokes at 25°C for the polyester resin. The resin shall be fresh material and should be used immediately on removal from its sealed container to avoid loss of volatiles.

**G-2 APPARATUS**

**G-2.1 Aluminium Plate**

100 × 100 × 6 mm with a 50 mm hole at the centre.

**G-2.2 Bull's Eye Paper**

*See* Fig. 3.

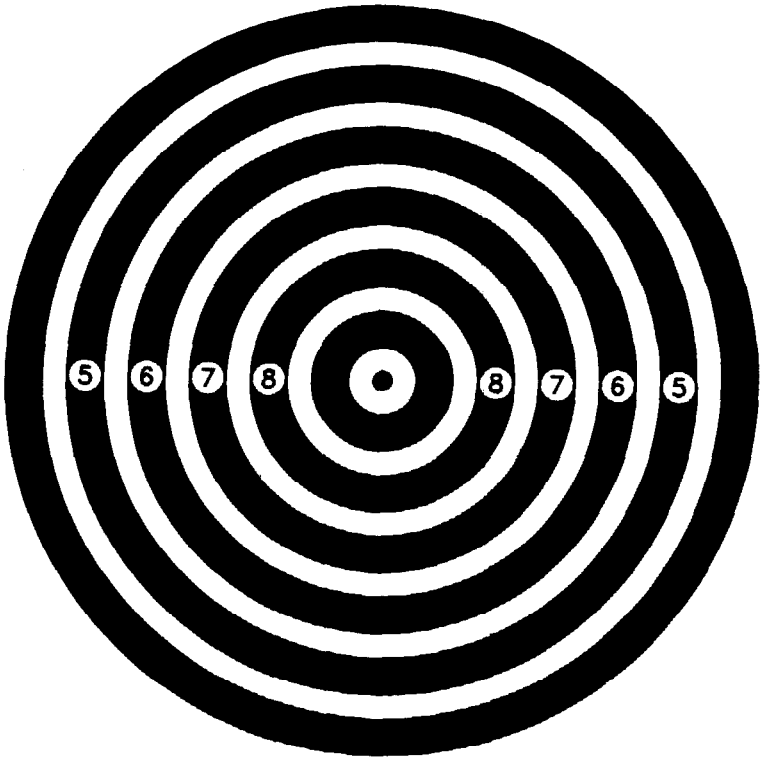


FIG. 3 TYPICAL BULL'S EYE PATTERN FOR WET-OUT TEST

**G-2.3 Polyester Film**

**G-3 PROCEDURE**

**G-3.1** Cut three specimens of chopped strand mat with the aid of a template 100 × 100 mm.

**G-3.2** Lay the bull's eye paper on a table and cover it with the polyester film.

**G-3.3** Place one specimen in position over the bull's eye.

**G-3.4** Over this specimen place the aluminium plate such that 50 mm hole centres over the bull's eye pattern.

**G-3.5** Pour the resin (epoxy, phenolic or polyester) into the hole as quickly as possible filling it up to the plate surface.

**G-3.6** Note the time taken (in seconds) for the black portion of the pattern to be visible by about 80 percent and the figures to be clearly legible.

**G-3.7** Repeat the test on the remaining two specimens.

**G-4 RESULTS**

**G-4.1** Report the average time of the three tests.

NOTE – Due to somewhat subjective nature of this test it is recommended that a series of materials to be compared shall be tested by one operator only preferably against results obtained from a standard mat used for comparison.

## ANNEX H

*( Foreword )*

## DETERMINATION OF BREAKING STRENGTH OF MAT

**H-0 GENERAL**

**H-0.1 Outline of Method**

This test determines the binding capacity of binder used for the manufacture of chopped strand mat.

### H-1 SPECIMENS

With the aid of a template, cut as many specimens 150 mm wide and 300 mm long across the mat as its width will allow when the 300 mm dimension is parallel to the length of the mat.

### H-2 PROCEDURE

Place each specimen in the 150 mm wide clamps of a tensile testing machine with a distance of 200 mm between the edges of the clamps. Employ suitable means, e.g. a rubber lining, to avoid crushing the mat in the clamps. Separate the clamps at 100 ± 10 mm/min and record the breaking force.

### H-3 RESULT

Report the breaking strength of the mat as the average of a minimum of five results (excluding jaw breaks) distributed equally across the width of the mat and also report the range.

## ANNEX J
*( Foreword )*
## DETERMINATION OF MAT BINDER SOLUBILITY

### J-0 GENERAL

#### J-0.1 Outline of Method

An indication of the ease with which a mat can be moulded is the time in which the mat binder can be dissolved in the resin itself.

### J-1 APPARATUS

The apparatus required consists of a dish and a loading frame ( *see* Fig. 4 ). The loading frame carries a stationery bulldog clamp and a second clamp, which is attached to a cord which carried a mass over a pulley. Two crossbars, of stainless steel or glass tubes of 10 mm outside diameter, are so positioned that their centres are 10 mm above base level. A stopwatch is also required.

### J-2 PROCEDURE

Prepare sufficient test liquid to fill the dish to a depth of 20 mm. Select the appropriate mass according to the mass per unit area of mat tested from Table 3 and attach it to the free end of the cord ( *see* Fig. 4 ).

Cut six 300 mm × 75 mm test specimen from the mat with their longer sides parallel to the length direction of the mat. Clamp 5 mm of one end of one specimen in the stationery bulldog clamp and the other end in the second clamp in such a manner that the bottom of the mass hangs approximately 25 mm above the level of the bench. Ensure that the specimen lies at right angles to the two crossbars. Place the loading frame in the dish and start the stopwatch. Stop the stopwatch when the mass falls and record this time. Test each of the remaining specimens and report the average of the determinations, together with their range.

**Table 3 Mass to be Used in the Mat Binder Solubility Test**

| Mass per Unit Area of Mat ($g/m^2$) | Mass (g) |
|---|---|
| (1) | (2) |
| 300 | 100 |
| 450 | 150 |
| 600 | 200 |
| 900 | 300 |

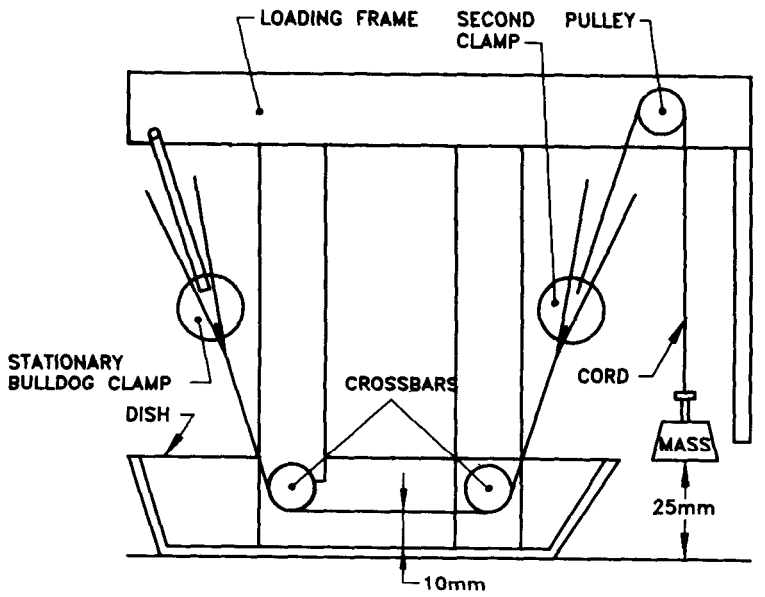


FIG. 4 APPARATUS FOR THE DETERMINATION OF MAT BINDER SOLUBILITY

## ANNEX K

*( Foreword )*

### DETERMINATION OF MAXIMUM AND MINIMUM RESIN PICK-UP

Depending on the application of the mat, the user may wish to employ a maximum or minimum amount of resin in the manufacture of the laminate. Cut 12 specimens 300 mm square from the mat. Weigh three of these together ( $M_1$ ). Impregnate the first of the specimens by applying with a spatula or palette knife the minimum quantity of resin necessary to cover it completely. Roll the mat with a split washer roller until all obvious air is excluded. Place the second on the first and impregnate it with the minimum amount of resin. Roll the mat until all obvious air is excluded. Place the third weighed specimen on the other two and impregnate it with the minimum amount of resin. Roll the mat until all obvious air is excluded. Weigh the uncured assembly of mat and resin ( $M_2$ ). Repeat this procedure with another three specimens. Calculate the resin/glass ratio $G$ from the following equation:

$$G = \frac{M_2 - M_1}{M_1}$$

Report the result as the arithmetic mean of these first two determinations. This ratio indicates the minimum amount of resin required to impregnate the mat.

To establish the maximum resin-holding capacity of the mat, repeat the procedure on the remaining specimens, but this time apply as much to each layer as is possible without pushing significant quantities of resin out of the mat during rolling.

Calculate the resulting resin/glass ratio as above and report the arithmetic mean of the second two determinations. This ratio indicates the maximum resin-holding capacity of the mat.

# ANNEX L

( *Foreword* )

## REQUIREMENTS FOR EPOXY RESIN SYSTEMS

| *Sl No.* (1) | *Characteristics* (2) | *Requirements* (3) |
|---|---|---|
| i) | Appearance | Clear, pale yellow liquid |
| ii) | Specific gravity at 25°C | 1.10-1.20 |
| iii) | Viscosity at 25°C, cps | 4 000-12 000 |
| iv) | Epoxy content, equivalent/kg | 5.20-5.45 |
| v) | Epoxy equivalent, g/equivalent | 184-192 |
| vi) | Colour (Gardner), *Max* | 2 |
| vii) | Volatile content, percent, *Max* | 0.75 |
| viii) | Hydrolysable chlorine, percent, *Max* | 0.20 |
| ix) | Flash point, Pensky-Martens,°C, *Min* | 200 |
| x) | Storage life at 25°C, Months, *Min* | 12 |

# ANNEX M

( *Foreword* )

## REQUIREMENTS FOR PHENOLIC RESIN SYSTEMS

| *Sl No.* (1) | *Characteristics* (2) | *Requirements* (3) |
|---|---|---|
| i) | Appearance | Clear, red-brown without any contamination |
| ii) | Specific gravity at 25°C | 1.20-1.30 |
| iii) | Viscosity at 25°C, cps ( Brookfield Viscometer ) | 500-650 |
| iv) | Solid content (135°C, 1h), percent | 72-80 |
| v) | *p*H | 6.5-7.5 |
| vi) | Water-tolerance, 25°C, percent | 70-85 |
| vii) | Cloud point, °C | 12-15 |
| viii) | Free formaldehyde, percent, *Max* | 1.5 |
| ix) | Free phenol, percent, *Max* | 5.0 |
| x) | Critical oxygen index of cast resin, percent, *Max* | 70 |
| xi) | Storage life at 25°C, Months, *Min* | 3 ( or as agreed to between the purchaser and the supplier ) |

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*( First Revision )*

[ *Page* 2, *Table* 1, *Sl No.*(vii) *col* 3 *to* 5 ] — Substitute '12.5' *for* 1.25'.

( PCD 12 )

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